PHOTOVOLTAICS (PV) VALUE CREATION IN EUROPE

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ABSTRACT: This paper proposes to assess the importance of Photovoltaics (PV) in Europe on the basis of value creation in Europe. The main goal of this paper is therefore to estimate the total value created by European PV activities. These activities consist of products and services found in the PV supply chain, not including the actual generation of electricity. A such, a thorough value chain analysis is carried out. That analysis includes a mapping exercise, where for each step in the PV supply chain, the main cost drivers or productive inputs are estimated. The results are two so-called Marri-Mekko charts, one for crystalline silicon and one for thin film PV. Based on that analysis, the value created by European PV activities is estimated at around 37 bn € in 2011. That is about 64% of the value of the European PV market in 2011 (58 bn €). In addition, O&M services related to the 22 GW newly connected PV systems in 2011 will trigger an additional value creation of almost 10 bn € over the next 25 years.
Keywords: PV Value Chain, Economic Analysis, PV System Price, Cost Drivers, Value Creation, Marri-Mekko charts

1 RATIONALE

It is clear that the growing geographical imbalance between the demand and supply of PV modules has raised concerns amongst policy-makers and negatively influences the public opinion. This results in growing opposition against PV and fierce debates on local content requirements or other trade barriers.

The underlying observation of an imbalanced demand and supply of PV modules is, however, entirely correct. The European PV market absorbed almost 22 GW of PV modules in 2011 and accounted for 74% of the global PV market (newly connected PV systems) [1a]. On the other hand, European PV cell and module manufacturers represented only 7% of the global cell and module supply in 2011, whereas the market share of Chinese and Taiwanese cell and module suppliers was 62% [2].

However, the simplistic view on counting only the production and installation of cells and modules is not sufficient and a more in-depth analysis for the whole value chain is needed. First of all, PV modules currently represent only half of the total value of a PV system. Other components (inverters and balance of system components) and installation services make up the other half. Secondly, shipment data for cells and modules do not take into account the other components necessary for the production of PV modules, such as PV equipment and materials. These are areas in which European companies typically hold strong positions – at least up to now.

Hence, this paper proposes to assess the importance of PV in Europe on the basis of value creation in Europe. The main goal of this paper is therefore to estimate the total value created by European PV activities based on a thorough PV value chain analysis. PV activities consist of products and services found in the PV supply chain, not including the actual generation of electricity. The value creation by European PV activities will then also be compared to the total value of the European PV market.

2 THE VALUE OF THE EUROPEAN PV MARKET

2.1 Market size and segmentation

In 2011, a total capacity of 21,939 MW of PV installations has been connected to the electricity grid in Europe, i.e. 74% of the global PV market [1a].

The segmentation used in this paper divides PV installations into three different types of systems. System sizes differ depending on the segment. Typically, a residential system will be smaller than 10kWp, a commercial/industrial system between 10kWp and 1MWp and a ground-based utility-scale system larger than 1MWp.

2.2 PV system price

PV system prices for eight specific countries, representing more than 90% of the European market, have been used in order to calculate European average system prices per segment (see Table I). Prices for the residential segment ranged between 3.20 €/W and 3.50 €/W; for the commercial/industrial segment between 2.55 €/W and 2.95 €/W and for the ground-based utility-scale segment between 1.95 €/W and 2.5 €/W [3a,4]. While taking into account different system prices for each segment, this paper neglects differences in system prices depending on the PV technology.

2.3 European PV market value

The value of the European market in 2011 is estimated at 58 bn €. Table I summarizes the data per segment.

Table I: Size, average system price and value of the European market – by segment

	%	€/W	m €
Residential	19%	3.32	11,162
Commercial/Industrial	54%	2.69	31,316
Utility-Scale (ground-based)	27%	2.23	15,526

3 PV VALUE CHAIN ANALYSIS

This section introduces the concept of Marri-Mekko charts to provide an in-depth overview of the PV value chain and its different cost drivers. The charts show the different steps in the value chain and the value of each step on the horizontal axis and the key cost drivers – also called productive inputs – on the vertical axis. Value chain services (logistics across the entire value chain) are not included in the analysis and the Marri-Mekko charts, but discussed separately in section 3.3 (Figure 3). Margins on the other hand are included in the analysis for each value chain step, but not shown separately. An industry average margin is discussed in section 3.4 (Figure 4).

Crystalline silicon (c-Si) and Thin Film (TF) technologies are treated separately because of the fundamental differences in the underlying value chain structure. C-Si technology represented 86% of the newly installed capacity in 2011, whereas TF technologies accounted for the remaining 14%, of which approximately 60% CdTe, 20% CI(G)S and 20% Si TF [2].

3.1 Crystalline Silicon (c-Si) PV Systems

The c-Si PV module represents with an average estimated price of 1.15 €/W approximately 50% of the total PV system value [2,3b,3c,4,8a]. The most important cost drivers are the equipment-related depreciation cost (more than 25%) and the material cost (almost 60%). Polysilicon production is the most capital-and energy-intensive step; depreciation and electricity costs together represent 80% of the total polysilicon production costs. Module assembly has the highest material cost; material inputs such as glass, EVA, backsheet, framing and the junction box represent almost 90% of the total module assembly cost. Direct labour input is relatively low (less than 5%); this is most likely lower than the current industry average. That is because the assumptions are based on data from the latest available equipment (see section 5 for more information concerning this assumption). Finally, electricity and overhead costs represent about 10% of the total PV module production costs. [5a,5b]

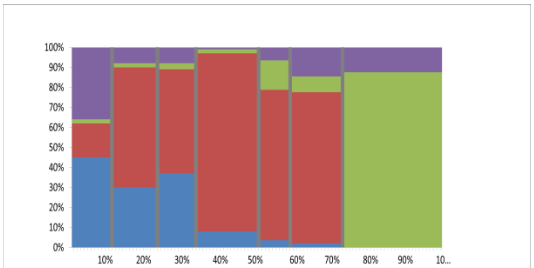

Figure 1: Marri-Mekko chart for the c-Si PV value chain

More downstream, the inverter and other balance of system (BoS) components, with average prices of 0.19 €/W and 0.32 €/W respectively, represent altogether 22% of the total PV system price [3c,6,7]. These prices are mostly determined by the underlying bill of materials [8b]. The installation itself requires mostly labour input (almost 90%) and represents 28% of the total system price [3b,3c,4,6,7,8a].

3.2 Thin Film (TF) PV Systems

For Thin Film PV systems, an average module price of 1.05 €/W was estimated, which represents only 48% of the total system price [2,3b,3c,4,8c]. Because TF PV modules are less efficient than their c-Si counterparts, the other, system-related costs are higher. BoS components costs were estimated at 0.37 €/W and together with the inverter they make up 25% of the total system price. Installation costs represent around 27% of the price of a TF PV system [3b,3c,4,6,7,8a].

Similar to the cost structure of a c-Si PV module, the material cost is the most important input factor for the production of TF modules (around 55%). Equipment-related depreciation costs represent, like for c-Si, more than 25% of the production cost [4]. For the remaining system-related components, the underlying cost structure is the same as for a c-Si PV system.

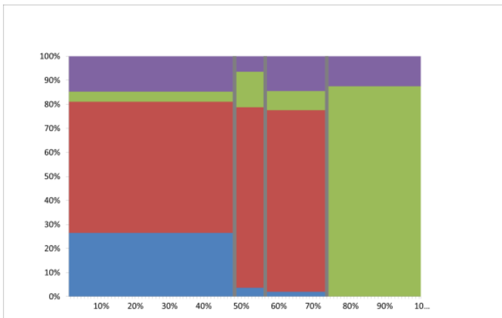

Figure 2: Marri-Mekko chart for the TF PV value chain

3.3 Value chain services (VCS)

As explained in the introduction to section 3, the costs related to transportation, storage and distribution (hereafter referred to as value chain services) are not included in the above analysis. That is because there is a lack of data to separate the cost of value chain services for each particular step in the PV value chain.

Figure 3 shows then, for an average PV system, the distribution of the different value chain steps – including value chain services as a separate step in the process. The average PV system has been calculated as a weighted-average of PV technologies and market segments. Value chain services seem to play an important role in the PV supply chain, as they account for 13% of the PV system price. This represents a total value between 7 and 8 bn € for the entire European PV market in 2011. It is clear that including the value chain services as a separate step in the analysis decreases the relative shares of the other PV value chain steps, e.g. a decrease from 49% to 43% for PV modules [6].

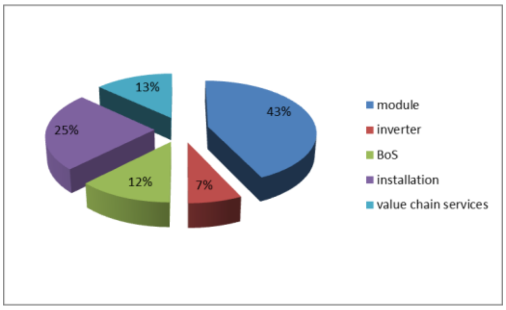

Figure 3: PV value chain steps

3.4 Margins

It is important to emphasize that the value chain analysis takes into consideration all the margins realized during each step of the value chain. In the above Marri-Mekko charts, margins were included but not depicted separately.

Figure 4 shows the relative contribution of each of the different input factors to the PV system price – describing the margins realized over the entire value chain as a separate cost driver. Like in section 3.3, the graph shows an industry average, based on a weighted-average of PV technologies and market segments. Material and labour inputs are the largest cost drivers, representing together more than half of the total PV system price. Margins make up 18%, overhead and electricity costs 15% and equipment-related depreciation costs 12% [3c,4,5a,5b,8b].

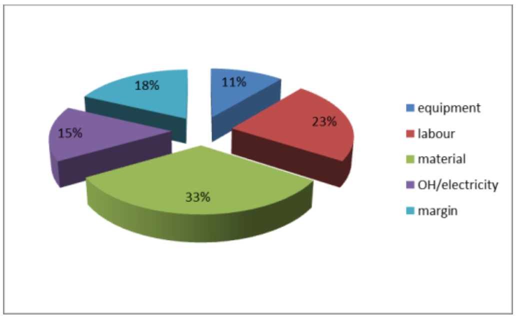

Figure 4: Cost drivers of the PV system price

3.5 Value distribution for the European PV market

In section 2, the total value of the European PV market was estimated at 58 bn €. The value chain analysis in section 3 showed the contribution of each of the different value chain steps and cost drivers to the total PV system price. Figure 5 combines the information in sections 2 and 3 and shows – for the European PV market – the total value (in bn €) for each of the value chain steps as well as the total value (in bn €) for each of the different cost drivers.

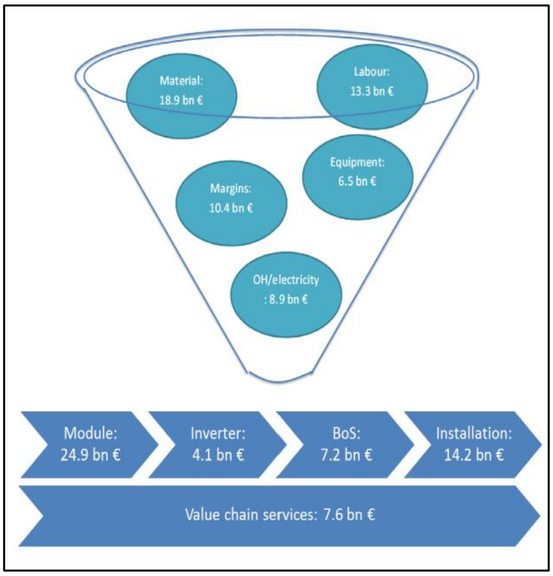

Figure 5: Value distribution for the European PV market

4 VALUE CREATION BY PV IN EUROPE

4.1 European Value Creation

Based on the results in section 2 and 3 and a number of estimations regarding the share of European-based production facilities and activities, the European PV-related value creation in 2011 is estimated at around 37 bn €, i.e. 64% of the value of the European PV market in 2011.

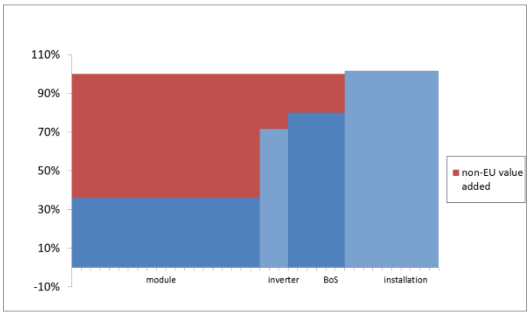

Figure 6: European value throughout the PV value chain

Whereas only 7% of the cells and modules are manufactured in Europe, the total value of European PV module manufacturing represents almost 9 bn €, i.e. more than 35% of the value associated with the PV modules placed on the European market in 2011. That is partly because the cell production and module assembly account for only 55% of the total PV module cost [5a,5b]. Another reason is the presence of a strong European manufacturing base for polysilicon (± 25% of the world's total), PV equipment (± 50%) and PV materials (± 25%), such as metallization paste, encapsulation materials, wire saws, etc. [1c,2,10].

The value of European inverter manufacturing was estimated at 3 bn € in 2011, assuming a market share of 80% for European-based inverter manufacturers with a correction for the sourcing of PV inverter materials, such as micro-electronics from elsewhere [1d]. For other balance of system components, such as cables, connectors and mounting structures, the European value creation is estimated to be between 5 and 6 bn €, i.e. 80% of the value of installed BoS materials in Europe. Value creation associated with installation services provided by European installers and project developers was estimated at almost 15 bn € [1b]. Finally, it was assumed that roughly 2/3rd of the activities related to value chain services took place in Europe, creating a value-added of around 5 bn €. The value chain services, however, are not depicted in figure 6.

4.2 European Export

It is important to understand that the export of European products and services to non-European PV markets has been taken into account. The total value of European export was estimated at approximately 3 bn €. As mentioned above, three main European export products are PV manufacturing equipment, PV materials and PV inverters. In addition, European project developers also export services related to PV project design and management.

4.3 Operation and Maintenance (O&M) services

Furthermore, the value of O&M services related to the installation of almost 22 GW of PV in 2011 is estimated at almost 10 bn €. This is calculated on the basis of a discounted value of the total lifetime O&M-related expenses for a period of 25 years. They include operators' costs and margins and an inverter replacement after 15 years [1b].

It is clear that with already more than 50 GW of PV installed in Europe, there will be a large market for optimization services and O&M activities. It is expected that in the long term, most jobs related to PV will be created in the field of O&M and other related servicing activities [11].

Finally, it should be noted that this paper does not take into account the value created through R&D activities carried out by universities or specialized research agencies. It neither acknowledges any value created by the actual generation of electricity or any other activities related to grid management or the implementation of smart grids.

5 ASSUMPTIONS AND SENSITIVITY ANALYSIS

Some of the assumptions in sections 3 and 4 of this paper could be challenged. For some of the assumptions, there was a lack of coherent data whereas for others, data sources were readily available, but the data do not necessarily reflect the current market situation.

For these assumptions, a sensitivity analysis has been performed. The results are summarized in Table II. The base case scenario (BCS) follows the assumptions as explained in sections 3 and 4. For each of the more 'critical' assumptions, a worst case scenario (WCS) is provided, as well as the effect of that WCS assumption on the total value creation in Europe (expressed in % of the total European PV market).

Table II: Sensitivity analysis

	BCS	WCS	Effect
Base case (BCS)			64%
Labour/equipment c-Si	2%/27%	10%/20%	-1%
EU share BoS	80%	50%	-4%
EU share PV equipment	49%	30%	-2%
EU share module materials	25%	12.5%	-3%
EU share VCS	67%	50%	-2%
EU share inverter materials	30%	10%	-1%

6 2012 AND BEYOND

Already in mid-2012, module prices as low as 0.5 €/W have been recorded and ground-based utility-scale PV systems are being built at prices around 1 €/W.

The low module prices due to significant overcapacity have triggered consolidation within the module and related upstream industry.. Moreover, there is limited short-term potential for cost reductions below above mentioned module price levels. In addition, because of increasing material prices and labour costs, BoS and installation costs are not expected to decrease rapidly in the coming years.

However, two main drivers for future cost reduction can be identified. First of all, improvements in module efficiency are crucial as higher efficiency modules require lower system-related BoS and installation costs. According to the well-known Price Experience Curve for Modules [reference my PVSEC paper: W. Hoffmann, S. Wieder, T. Pellkofer, PVSEC 2009, Hamburg] a price for c-Si modules at 0.5 €/W (0.65 $/W) would not be expected at todays cumulated volume of about 70 GW but at a much higher volume beyond 200 GW. Only at a cumulated experience in this range there will be sufficient margins for all players in the value chain. Secondly, stable and continued market growth will help drive down distribution and other costs related to value chain services. It will moreover trigger further cost reduction in the BoS and installation through economies of scale, improvements in handling of mounting structures and establishing a network of well-trained installers.

7 CONCLUSIONS

The purpose of this paper is to propose an assessment method to measure the importance of PV in Europe, based on the actual value creation in Europe instead of shipment data of PV components. Building on the results of a thorough value chain analysis, value creation by European PV activities in 2011 is estimated at around 37 bn €. That is as much as 64% of the 58 bn € value of the European PV market in 2011. In addition, O&M activities related to the 22 GW installed PV systems in 2011 will trigger a further 10 bn € of value-added over the next 25 years.

Further research is required and will help to clarify some of the assumptions for which only limited data was available, notably on PV materials, BoS components and value chain services.

Finally, it is important to understand that the PV industry today is in fact already a global industry with a global supply chain, very much like the electronics industry or automotive industry. One of the main goals of this globalized industry is to drive costs further down in order to become even more competitive in tomorrow's energy markets. Therefore, world-wide cooperation is key, with players throughout the entire supply chain working together to improve PV technology and governments world-wide cooperating to build a stable, global PV market.

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